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(54) Contact reactor.

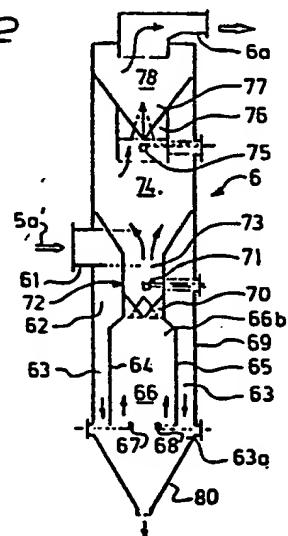
(57) A contact reactor (6) through which a contaminated medium (5a') is caused to pass and into which there is introduced an absorbent (67, 68) capable of reacting with the contaminants carried by the medium, means (67, 68) being provided for mixing the medium with the absorbent. In accordance with the invention wall sections (64, 65) forming part of the contact reactor define a reactor chamber (66), into which a finely-divided liquid or a slurry is introduced and brought into contact with the flow of contaminated medium. The wall sections are heated by the flow of contaminated medium (5a') of the high temperature, this flow of contaminated medium passing the wall sections (64, 65) via a slot-like spacing (63) in a manner to deliver heat to the wall sections, whereafter the contaminated medium passes into the reactor chamber (66).

A1

EP 0 200 695

Turbulence-generating means (70) are arranged downstream of the reactor chamber (66), while a means for supplying powdered absorbent (70) is arranged downstream of the turbulence-generating means (70).

FIG. 2



TITLE OF THE INVENTION:CONTACT REACTORTECHNICAL FIELD

The present invention relates to a contact reactor and more particularly, although not exclusively, to a contact reactor of the kind through which a contaminated medium, normally a contaminated gas flow, is passed, and to which there is supplied an absorbent capable of reacting with the contaminants carried by the medium, and which incorporates means for mixing the contaminated medium and the absorbent together.

10

BACKGROUND PRIOR ART

When the contaminated medium has the form of a contaminated gas flow, it is known when practising totally dry methods, and even when practising wet-dry methods, in contact reactors of this kind to carry out the actual gas-cleansing process at temperatures which lie as close as possible to the dew-point of the gas concerned. By lowering the temperature in this regard it is possible to moisten slightly the dust or contaminants present in the gas and therewith improve absorption and render the reaction between the absorbent and the acid components more effective.

It has also been established that a low working temperature during the actual gas cleansing process improves the extent to which gaseous heavy metals and various organic components are extracted from the gas.

Those experiments which have already been carried out in practice show unequivocally that when cleansing a gas in accordance with the foregoing there is found a lowest temperature limit at which the gas can be cleansed with simple means. For example, if the temperature of the gas falls beneath this lowest temperature limit, the water content of the dust increases and eventually becomes so high as to make it impossible to handle the dust in a dry state.

It has also been established that when sulphur dioxide is absorbed with the aid of slaked lime, the dew-point temperature of the gas constitutes a lower limitation of the working temperature.

5

It is well known that the composition of gases generated in incinerators or waste combustion plants is highly complex, and that hydrogen chloride predominates among the acid compounds to be removed.

10

The hydrogen chloride together with the calcium hydrate present forms calcium chloride which is extremely hygroscopic and since the water absorption factor of this salt increases with decreasing temperature, the working temperature is limited downwards.

15

It is also known in this particular art to conduct flue gases along the outer surfaces of the flue ducts or conduits prior to introducing the flue gases into the contact reactor, in order to heat the walls of the ducts and therewith avoid the formation of dust deposits on the inner surfaces of the walls.

20

An example of this technique is described and illustrated in Swedish Published Specification No. 441,151.

25

This published specification describes a contact reactor in which certain wall sections are heated with the aid of the incoming hot gas, in order to prevent the formation of deposits on the inner surfaces of the wall sections.

30

It is also disclosed in said publication that acid or other harmful substances present in the flue gases downstream of an incinerator or combustion means can be neutralized by introducing along a contact path in a section of a flue-gas conduit, with the aid of spray nozzles, a neutralizing medium comprising, for example, a suspension of solid basic particles, such as a lime/water suspension.

The published specification also discloses that the flue gas is passed through an annular passageway and then deflected through 180°, so that the gas is able to pass through an inner conduit previously heated by the flue gases.

#### SUMMARY OF THE INVENTION

#### TECHNICAL PROBLEMS

When considering the present state of the art as discussed in the foregoing it will be seen that a technical problem resides in providing with the aid of simple constructive measures a contact reactor which can be considered to embody within itself a cyclone separator suitable for separating coarse particulate substances or compounds from the medium being treated in the reactor.

It will also be seen that a further technical problem resides in providing within a contact reactor, with the aid of simple constructive measures, conditions which enable coarse contaminants to be extracted from a gas flow before the reaction in the reactor chamber can commence. This is of particular importance when recycling absorbent material, since recycling requires the absence of coarse particles.

A further technical problem is one of creating with the aid of simple constructive measures conditions which enable coarse contaminants to be separated from a gas flow, by deflecting a downwardly directed circulating gas flow upwardly through 180°.

Another technical problem resides in the provision of simple means which enable wall sections located in a reactor chamber adjacent turbulence-generating means to be heated by a flow of hot gas while the remaining wall sections of the reactor chamber downstream of the turbulence-generating means are heated with a gas flow under a cooling effect.

Experience has shown that in contact reactors of this kind, the aforementioned build-up of dust deposits does not commence until excessively low gas temperatures are reached, and consequently it is highly desirable that the  
5 wall temperature does not fall beneath a predetermined level, despite liquid being added in order to increase the reactivity of the absorbent. The provision of conditions which satisfy this need constitutes a further technical problem in the present context.

10

A further technical problem resides in the provision of conditions which will enable flue gases to be cleansed in several stages in a single contact reactor, these stages consisting of a first stage in which coarse contaminants  
15 are extracted from the gas in a cyclone separator, a second stage in which the gas is cleansed with the aid of a slurry; and a third stage and further stages in which the gas is cleansed with the aid of a powdered absorbent; and also in the provision of conditions which enable the powdered absorbent to be used and recycled more effectively.  
20

#### SOLUTION

The present invention relates generally to a contact reactor through which a contaminated medium, normally a stream  
25 of contaminated gas, is passed, and into which reactor there is introduced a slurry of absorbent material capable of reacting with the contaminants carried by the medium. Means are also conveniently provided for mixing the contaminated medium with the absorbent.

30

In accordance with the invention part of the reactor wall defining a reactor chamber, into which a finely-divided liquid or a slurry is introduced for contact with the medium, is heated so as to reduce or to eliminate the  
35 build-up of powdered absorbent deposits as a result of condensation.

It is particularly proposed in accordance with the invention that the contaminated medium is introduced through a tangential inlet into an annular space which surrounds the reactor chamber and which has a large cross-sectional area adjacent the inlet and a smaller cross-sectional area in the proximity of the wall sections of the chamber, so as to increase the velocity of the flow of contaminated medium and therewith create conditions for separating coarse contaminants from the medium flow prior to deflecting or turning the flow through 180°, for passage into the chamber; and that during its passage through the chamber the flow of medium is arranged to deliver heat to the wall sections of the chamber.

In accordance with one advantageous embodiment of the invention means are provided for introducing the liquid or slurry into the reactor chamber at a point which lies in or immediately adjacent to the region at which the flow of medium is turned to flow into the reactor chamber.

In addition, it is proposed that turbulence generating means are arranged adjacent wall sections exposed to a flow of medium of high temperature, these means being located in the vicinity of the inlet to the surrounding space but within the reactor chamber.

It is also proposed that a narrowing section incorporating a turbulence-generating means is provided downstream of the chamber and that powdered-absorbent supply means are located downstream of the turbulence-generating means.

In accordance with one embodiment of the present invention the aforementioned wall sections define therebetween a cylindrical or substantially cylindrical chamber, which serves as a vaporizing zone for vaporizing the liquid and/or the slurry present in the flow of medium.

Conveniently, an annular slot-like space is formed around

the wall sections, this slot-like space being defined by the outer surface of the wall sections and the inner surface of a contact-reactor mantle or shell arranged to guide the medium downwardly.

5      In accordance with the invention, the medium or gas flow is introduced tangentially into the contact reactor, and into a cylindrical space whose cross-sectional area is larger than the cross-sectional area of the slot-like space.

10     The medium is conveniently permitted to circulate in the cylindrical space, or chamber, and to pass therefrom down through the slot-like space, at the bottom of which means are provided for turning the flow of medium through 180°, such that the medium immediately flows into the reactor

15     chamber subsequent to delivering part of its heat content to the defining wall sections, and also means for removing coarse contaminants from the medium or gas flow.

In order to cool the medium or gas still further, means

20     20 may be provided for supplying liquid and/or slurry, the liquid being intended to cool the medium while the purpose of the slurry is to cool and to react with and absorb the contaminants carried by the medium. This means is arranged to direct a jet of liquid or a curtain of liquid upwardly

25     25 into the reactor chamber. The means is positioned downstream and adjacent the region where the flow of medium is turned or deflected.

In the case of a contact reactor in which the contaminated

30     30 medium is cleansed in accordance with the dry method principles, the section of the reactor located downstream of the cylindrical chamber narrows and incorporates particularly turbulence-generating means, in order to increase the velocity of the medium flow. First means for supplying

35     35 a powderous absorbent are arranged immediately downstream and above the turbulence-generating means.

In accordance with one advantageous embodiment of the

invention the turbulence-generating means and the first powderous-absorbent supply means are incorporated in a tubular element which is located adjacent the cylindrical space or chamber of large cross-sectional area.

5

Located downstream of the aforesaid first supply means is a mixing zone, while downstream of the mixing zone there is provided a reaction section of large cross-sectional area.

10

In accordance with the present invention, a second means for supplying powderous absorbent is located adjacent the downstream part of the reaction section. Located downstream of the second supply means is a turbulence-generating means and a mixing section, and also a further reaction section, prior to cleansed medium or cleansed gas being permitted to pass from the contact reactor.

In accordance with the invention and adapted to a contact reactor working in accordance with the totally dry method, the incoming gas is arranged to first pass down through the reactor, subsequent to circulating in the upper chamber of the reactor, and to then turn upwardly and pass through the centre of the reactor. The inlet through which the contaminated medium is introduced into the reactor should be located approximately at the midway point thereof.

#### ADVANTAGES

30 Those advantages primarily afforded by a contact reactor constructed in accordance with the present invention reside in the possibility of cleansing a contaminated medium in a multiple of stages, incorporating a first stage in which coarse particulate contaminants are extracted from  
35 the medium in a cyclone separator, a second stage effected in a chamber in which a finely divided liquid or a slurry is brought into contact with the medium and the wall sections of which chamber are heated so as to prevent the

0200695

build-up of particulate absorbent on the surfaces thereof, and a third stage and further stages in which the medium is further cleansed with a dry absorbent powder. In addition hereto, conditions are created in which turbulence 5 is generated prior to supplying the powdered material.

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The primary characteristic features of a contact reactor 10 constructed in accordance with the present invention are set forth in the characterizing clause of the following Claim 1.

- - - - -

15 BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention having features characteristic of the present invention will now be described in more detail with reference to the accompanying drawings in which

20 Figure 1 is a schematic, sectional side-view illustrating a gas cleansing plant of principally known construction; and

Figure 2 is a sectional side-view of a contact reactor constructed in accordance with the invention and capable of being incorporated in the plant illustrated in Figure 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Figure 1 is a schematic sectional side-view illustrating 30 a gas cleansing plant of principally known construction for illustration purposes.

The complex illustrated in Figure 1 includes a boiler house 1 and a heat exchanger 2 which is constructed for 35 use with hot flue gases and which is adapted to transfer heat from the gases to furnace air of combustion, supplied to the boiler by means of a fan 3.

0200695

The flue gases pass through a conduit 4 to an electrostatic precipitator 5 which is connected to a contact reactor 6 by a duct or conduit 5a. A flow of contaminated gas 5a' passes through the duct 5a and into the contact reactor 6. The contaminants carried by the gas may be in particle form or in gas form, such as hydrogen chloride, sulphur dioxide for example.

Arranged in the upper part of the contact reactor 6, which 10 operates in accordance with wet-dry gas-cleansing principles, is a number of nozzle assemblies 10' in which a first medium, in the form of air, entering through a pipe 10a, is mixed with a second medium in the form of lime particles suspended in water, entering through a pipe 10b connected to a 15 lime and water mixer 10c. The mixture produced in respective mixing nozzle assemblies and comprising air and an aqueous lime suspension for absorptive reaction with the contaminants in said flow of contaminated medium is introduced into the medium flow through one or more of the aforesaid 20 nozzle assemblies 10'.

The partially cleansed medium, or gas flow, passes from the contact reactor to a hose filter 7, through a pipe 6a. The medium is further cleansed in the hose filter 7, and 25 is then passed through a duct or pipe 7a to a fan 8, which drives the cleansed gases through a pipe 8a and out through a chimney or smoke stack 9.

Thus, the flue gases cleansed in a number of mutually separate stages are discharged through the smoke stack or 30 chimney 9 with the aid of said fan 8.

In Figure 2 there is illustrated a contact reactor 6 which is constructed in accordance with the invention and in 35 which the gas is cleansed in accordance with dry-method principles, which reactor can be used to advantage in the gas cleansing plant according to Figure 1.

Thus, Figure 2 illustrates a contact reactor through which there is passed a contaminated medium 5a', or gas flow, and into which there is introduced an absorbent capable of reacting with the contaminants carried by the medium, this 5 medium being referred to hereinafter as the contaminated gas flow.

The contaminated gas flow 5a' enters the contact reactor through a tangential inlet 61, which in this embodiment 10 comprises a connector stub, located at the midpoint of the reactor and flows into a cylindrical chamber or space 62, which merges with a narrower cylindrical slot-like space 63.

15 The gas flow 5a' circulates within the chamber and eventually moves down through the slot-like space 63 past wall sections 64,65 while delivering part of its heat content thereto.

20 The wall-sections 64,65 define therebetween a reactor chamber 66, into which a finely-divided liquid or slurry is introduced through nozzles 67,68. As illustrated by the arrows in Figure 2, the gas enters the reactor chamber 66 through the bottom thereof, after transferring part of its 25 heat content to the wall sections 64,65.

Liquid or slurry is introduced into the reactor chamber through the nozzles 67,68 for the purpose of cooling the 30 gas or for absorbing contaminants carried thereby into said chamber, which acts as an evaporating zone, so that the temperature slightly exceeds the dew-point temperature.

The inner surfaces of the wall-sections 64,65 shall be heated to a temperature well above the dew-point tempera- 35 ture of the gas flowing into the reactor chamber 66, in order to reduce, or even to eliminate, the build-up of dust deposits on the inner surfaces of said wall sections.

As clearly illustrated in Figure 2, the high-temperature gas entering the contact reactor first passes the outer surfaces of the wall-sections 64,65 while delivering part of its heat content to said outer surfaces, and is then 5 turned or deflected through 180° and enters the reactor chamber 66 in a slightly cooled state.

As will be seen from Figure 2, the wall-sections 64,65 define a cylindrical or substantially cylindrical space 10 in which there prevails a temperature sufficiently high to vaporize liquid and/or slurry passing through the nozzles 67,68, which are located at the bottom 63a of the slot-like space 63.

It will also be seen from Figure 2 that the cylindrical slot-like space 63 surrounding the wall-sections 64,65 is defined outwardly by the inner surface of contact-reactor mantle or shell 69, the diameter of which is substantially equal to the diameter of the space or chamber 62 into which 20 the gas first enters the reactor through the tangential inlet 61. Gas circulating in the chamber 62 eventually becomes crowded and as a result moves rapidly down through the slot-like space 63, means being located at the bottom 63a of the space 63 for mixing and turning the gas flow 25 into the chamber 66.

As the gas flow leaves the slot-like space 63 and turns to enter the reactor chamber 66, coarse contaminants carried by the gas fall down into a collecting bin or pre-separator 30 80 located beneath the space 63.

The nozzles 67,68 or means for supplying liquid and/or slurry to the reactor chamber for cooling and/or absorbing the contaminated medium or the contaminants carried 35 thereby are arranged to direct a jet of liquid or a curtain of liquid upwardly into the reactor chamber 66, the nozzles 67,68 being located downstream and immediately adjacent the region at which the gas flow is forced to

turn through 180°.

The upper part 66b of the reactor chamber 66 narrows and incorporates turbulence-generating means 70.

5 Located immediately downstream of the turbulence-generating means 70 is a first means 71 for supplying powdered absorbent. The turbulence-generating means 70 and the first powdered-absorbent supply means 71 are formed in a tubular element 72 located centrally in the reactor chamber 62, which has a large cross-sectional area in relation to the cross-sectional area of the slot-like space 63.

15 Arranged downstream of the first supply means 71 is a mixing zone 73 and downstream of the mixing zone 73 there is provided a reaction section 74, the cross-sectional area of said section corresponding to the cross-sectional area of the reactor mantle or shell 69.

20 The downstream located part of the reaction section 74 incorporates a second supply means 75 for supplying powdered absorbent. Located downstream of the second supply means 75 is a turbulence-generating means 76 and a mixing section 77, and also a further reaction section 78, in which the gas is further cleansed prior to being discharged through an outlet 6a.

As before mentioned, a pre-separator 80 intended for extracting coarse contaminants is arranged beneath the nozzles or means 67,68 for introducing liquid and/or slurry into the reactor chamber.

35 In order to minimize the consumption of alkali, it is important that separated material containing unused alkali can be recycled. This recycling of material is most often effected subsequent to slurring with water in the case of wet-dry methods, and subsequent to intermediate storage of the material in the case of a totally dry method. It is

**0200695**

desirable in both cases to recycle as much non-reacted material as possible, and therewith minimize the extent to which inert material is recycled from the combustion process. To this end, it is proposed that the aforesaid 5 pre-separator 80 is located between the combustion process and the reactor.

With regard to the construction of the turbulence-generating means 70 and 76, reference is made to the arrangement 10 illustrated and described in European Patent Application 85850382.4, filed 26 November 1985.

Thus, Figure 2 illustrates a contact reactor adapted to operate in accordance with the wet-dry method and to 15 operate in several stages in accordance with the fully dry method.

It will be understood from the aforesgoing that the gas flow 5a' is arranged to first sink down through the outer 20 region of the contact reactor, i.e. the slot-like space 63, and to then turn and rise through the whole of the central region of the contact reactor.

Consequently, the gas-flow inlet 61 is located in or substantially 25 in the midway point of the reactor.

It will be understood that the invention is not restricted to the aforescribed embodiment and that modifications can be made within the scope of the following claims.

The coarse particles are separated as in a cyclone separator and falling down while the gas is ejected into the reactor chamber by the nozzles 67 and 68 and passing in the direction upwards in the chamber 66.

0200695

CLAIMS

1. A contact reactor of the kind through which a contaminated medium (5a') is passed and in which there is supplied an absorbent capable of reacting with the contaminants carried by the medium, and which incorporates  
5 means for mixing the contaminated medium with the absorbent, and which reactor incorporates wall sections which define a reactor chamber into which a finely-divided liquid or a slurry is introduced (67,68), and which wall sections are arranged to be heated, characterized in that  
10 contaminated medium is arranged to be introduced tangentially into a space surrounding said chamber through an inlet herefor; in that the surrounding space has, in the region of said inlet, a large cross-sectional area and in the region of the wall sections defining said chamber  
15 a smaller cross-sectional area, so as to impart a higher velocity to the flow of medium and therewith create conditions for separating coarse contaminants therefrom prior to the flow of medium being turned through 180° for passage into the reactor chamber; and in that the flow of medium is  
20 arranged to deliver heat to the defining wall sections during its passage to said chamber.
2. A contact reactor according to Claim 1, characterized in that the liquid or the slurry is arranged to be introduced  
25 into the chamber through means located in or immediately adjacent the location at which the medium flow is turned through 180°.
3. A contact reactor according to Claim 1 or Claim 2,  
30 characterized in that arranged in the vicinity of the inlet in the surrounding space but within the reactor chamber are turbulence-generating means positioned adjacent wall sections contacted by a flow of medium of high temperature.
- 35 4. A contact reactor according to any of the preceding Claims, characterized in that downstream of the reactor

chamber (66) there is provided a narrowing section (66b) incorporating a turbulence-generating means (70); and in that a means (71) for supplying powdered absorbent is arranged downstream of the turbulence-generating means (70).

5

5. A contact reactor according to Claim 1, characterized in that the wall sections (64,65) are arranged to define a cylindrical or substantially cylindrical chamber (66) serving as a vaporizing zone for the aforesaid liquid and/or slurry.

10

6. A contact reactor according to Claim 1 or Claim 5, characterized in that the wall sections (64,65) are encircled by a slot-like space (63) defined by said wall sections and a contact-reactor mantle or shell (69), which is operative in conducting the contaminated medium (5a') in a downward direction.

15

7. A contact reactor according to Claim 1, 5 or 6, characterized in that the medium (5a') is arranged to be introduced into a space (62) of large circular cross-section; in that the medium (5a') is then permitted to pass said slot-like space (63), via a rotational movement; and in that means (67,68) are provided adjacent the bottom of the slot-like space for turning the flow of medium into the chamber (66), the wall sections (63,64) of which are heated; and in that means are provided for removing coarse contaminants.

20

30

8. A contact reactor according to Claim 1, characterized in that means (67,68) for supplying liquid and/or slurry for cooling the contaminated medium and absorbing the contaminant carried thereby are arranged to direct a curtain of liquid upwardly into the chamber (66); and in that said means is located downstream adjacent the region (63a) in which the flow of medium is turned.

35

9. A contact reactor according to Claim 1, characterized in that first means (71) for supplying a powdered absorbent is located immediately downstream of the turbulence-generating means (70).

5

10. A contact reactor according to Claim 1 or Claim 9, characterized in that the turbulence-generating means (70) and the first powdered-absorbent supply means (71) are formed in a tubular element (72) surrounded by the space

10 (62) of large cross-sectional area.

11. A contact reactor according to Claim 9, characterized in that a mixing zone (73) is provided downstream of the first supply means (71), and in that a reaction section (74) of large cross-sectional area is located downstream of the mixing zone.

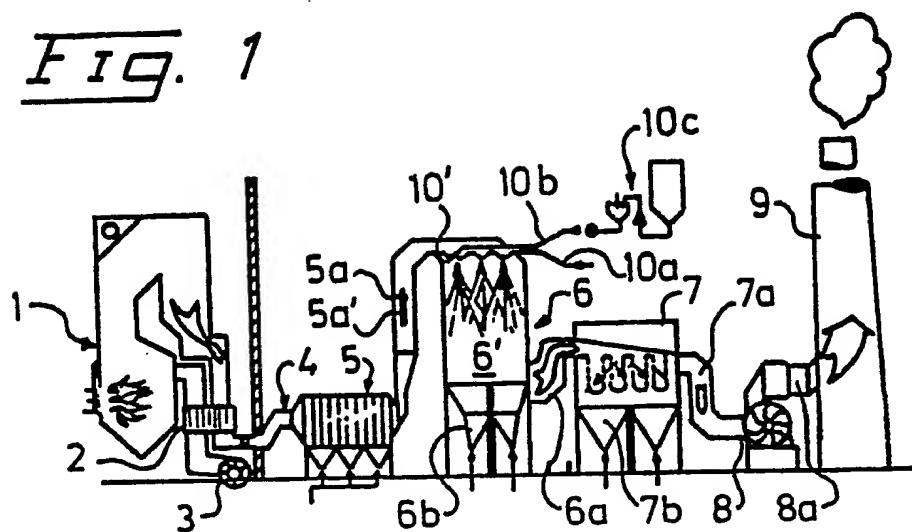
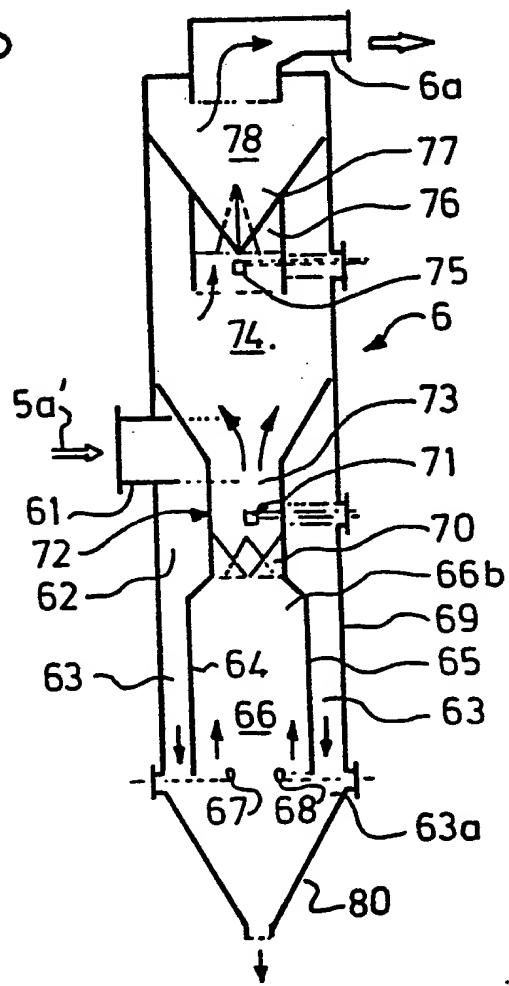
12. A contact reactor according to Claim 11, characterized in that the downstream part of the reaction section (74) incorporates a second means (75) for supplying powdered absorbent.

13. A contact reactor according to Claim 12, characterized in that arranged downstream of the second supply means (75) is a turbulence-generating means (76), a mixing section (77), and a further reaction section (78).

14. A contact reactor according to Claim 1, characterized in that a pre-separator (80) for coarse contaminants is arranged beneath the means (67,68) for supplying liquid and/or slurry.

15. A contact reactor according to Claim 1, characterized in that the flow of medium (5a') is first arranged to be conducted downwardly, via a rotational movement, and then upwardly, so as to rise through the whole of the contact reactor while being cleansed therein.

16. A contact reactor according to Claim 1 or Claim 15, characterized in that an inlet (61) for the flow of contaminated medium (5a') is located at least substantially at the midway point of the contact reactor.

FIG. 1FIG. 2



| DOCUMENTS CONSIDERED TO BE RELEVANT  |   |                   |   |
|--|---|-------------------|---|
| Category   | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4)                         |
| A  | SE-B-422 006 (INVENTA AG)<br>-----  |                   | B 01 D 53/18  |
| A  | SE-B-427 529 (AS NIRO ATOMIZER)<br>-----                                      |                   |   |
| A  | SE-B-429 010 (FLÄKT AB)<br>-----  |                   |   |
| X  | DE-A-2 116 996 (SHOWA DENKO)<br>-----   |                   |   |
| X  | SE-B-416 380 (WIEGAND KARLSRUHE GMBH)<br>-----                                | 1-16              |   |
| X  | SE-B-427 423 (WIEGAND KARLSRUHE GMBH)<br>-----                                | 1-16              |   |
| X  | SE-B-429 724 (FLÄKT AB)<br>-----  | 1-16              | <b>TECHNICAL FIELDS<br/>SEARCHED (Int. Cl.4)</b><br><br><b>B 01 D</b> |
| The present search report has been drawn up for all claims                       |   |                   |   |
| Place of search  | Date of completion of the search  | Examiner          |   |
| STOCKHOLM  | 27-06-1986  | LUNDELL B-M.      |   |
| CATEGORY OF CITED DOCUMENTS  |   |                   |   |
| X : particularly relevant if taken alone   | T : theory or principle underlying the invention                              |                   |   |
| Y : particularly relevant if combined with another document of the same category | E : earlier patent document, but published on, or after the filing date       |                   |   |
| A : technological background   | D : document cited in the application   |                   |   |
| O : non-written disclosure   | L : document cited for other reasons  |                   |   |
| P : intermediate document  | & : member of the same patent family, corresponding document                  |                   |   |